



Anaco Stainless

Experts in stainless steel for engineering and construction

A Precast Destiny?

A general overview of the use of stainless steel reinforcement in precast concrete structures.

The combination of concrete and steel is a delightful one. It enables the concrete to express its most plastic qualities. That is until the effects of corrosion weaken the structure. The influence of chloride ions; progressive reduction in pH over time of the concrete; poor quality concrete or even, unimaginably, poor workmanship will reduce the service life of a structure unless steps are taken at the outset of design to accommodate these risks.

Many readers will be familiar with the 'Law of Fives': £1 spent extra wisely today will save £5 in defects and snagging; £25 in future repairs; and £125 in structure replacement at a future date. All the data on problems relating to corrosion prove this proposition.

There are many methods that seek and promise to prevent corrosion in reinforced concrete. Many offer technically 'sexy' approaches. They do often reward the customer with cheap initial project costs. Cynically, the contractor and related engineers have the promise of years of future work in repair and maintenance -devising ever more complicated forms of either slowing, replacing or side-stepping the issue of corrosion!

The loser in the wonderful dynamic of creation and degradation is the client who has to foot the bill - ultimately the taxpayer. Very often, the hapless taxpayer is subsidising the parsimonious mistakes both of past decisions and our politicians' blind priorities.

In reinforced precast concrete, we have a good example of where the balance of the concrete and stainless steel reinforcement comes as close to perfection as possible.

The use of precast offers factory production quality with far greater controls on placement of reinforcement resulting in even cover between structure surface and reinforcement within. The resultant product is consistent: giving little or no variation in cover often arising with in situ conditions which are always unique - varying from one hour to the next.

We now introduce into the equation stainless steel reinforcement. This material does not corrode. It is forgiving in precast as well as in situ environments.

The use of stainless steel reinforcement allows for reduced

cover and relaxation of crack-widths (see Highways Agency Advice Note BA84/02). From an architectural and aesthetic standpoint, the beauty of exploiting reduced cover will result in the creation of more slender and elegant structures. These can obviously be best produced in controlled factory environments.



Stainless reinforcement provides maintenance free long-term structures. The material is environmentally friendly benefiting from being fully recyclable at the end of the life of the structure.

Flexibility of Use with High Tensile Carbon Steel Reinforcement:

It is now approved practice that stainless and carbon steel reinforcement can be coupled in the presence of concrete without any risk of initiating a galvanic reaction between the two metals (Highways Agency Advice Note BA84/02). No isolators are required when coupling the two materials. This means that stainless steel can be used highly selectively in a structure where limited cover may be required or where part of the structure is in danger of being exposed to an aggressive environment - such as chloride ions. This allows for seamless transitions from the one metal to the other in the presence of concrete. Since stainless steel conforms mechanically with High Tensile carbon steel, it follows the same design criteria set out in BS8666:2005 and is detailed accordingly.

For example, decorative panelling on a sea front which is precast, may have the front of the panel reinforced with stainless reinforcement but the rear may only require carbon steel reinforcement. Equally the upstand of a sea wall may be reinforced with stainless and the base which has both thicker cover and may be further removed from direct chloride attack may be in High Tensile lapping into stainless in the upstand section.

It must be noted, however, that the processing (cutting and bending) of stainless must be undertaken on machinery clean of any carbon steel contamination. If carbon steel is impacted into the stainless steel during processing for a project, it may run the risk of future pitting corrosion.

With this knowledge, the specifying engineers do not need to worry about treating stainless steel 'specially' in terms of design.

Selective Use:

Stainless steel is an expensive material. It tends to track the cost of high tensile carbon steel at between 4 and 12 times the cost. But selective use in areas of high risk chloride ion penetration or premature carbonation ensure that the impact of cost is not an issue. It's cost impact which needs to be analysed as part of the project as a whole and not in isolation. It is our contention that selective use essentially eliminates the need to justify its use by means of Whole Life-Cycle Cost Analysis techniques. Equally, where, for whatever reason, a disproportionate quantity of stainless reinforcement is used, such analyses do indicate benefit through reduced maintenance liabilities in future years.

Environmental Benefits Linked to the Use of Stainless

By reducing cover of the concrete, there is a saving on the quantity of cement used which is environmentally beneficial. Reduction in the quantity of concrete means a lighter precast structure and, or, component. This may help ease overall logistics costs – both in terms of transportation and eventual placement on site – lifting costs and structural loading.

Project Examples, Areas of Development and Benefits:

Durability in passive surroundings:

The first two examples used in this article are a shameless exploitation by the author of the long term nature of the structures' eventual designed for use, namely, linked to educational institutions. The proverb "kissin' don't last but cookin' do" could equally be applied to the timeless nature of "... learnin' do" -our educational establishments.

The first example is the use of stainless in the steps of post graduate residences for Balliol College at the Masters' Fields in Oxford. Here is a very attractive use of a coloured aggregate with very thin cover in a passive environment. It is designed to last. The tightness of space within the stairwell encourages the architect and specifying engineer to use slender steps. Due to the desired for 'longevity', the only solution was stainless reinforcement. Cover in this case was limited to 15 mm with minimum 40 MPa concrete strength. Again, the benefit is more than just elegance in a limited

space, it also has logistical advantages for transportation and erection.

The second example features Westminster University in London: one of Britain's more recent universities which will undoubtedly be around for centuries to come. Here the architects were primarily interested in efficiency of delivery and overall loading linked to a bright white pigment concrete. The need to avoid bleeding through the precast units at some point in the future and so damage the appearance of the building is clearly an important feature of successful design planning. The benefit of using stainless reinforcement was again fully utilised in this case. The engineers only used 20 mm cover with a min. 40 MPa concrete strength.

In both cases: Balliol College and Westminster University, the simplest of the stainless steel alloys was used, namely, Steel Designation No.: EN1.4301 or, in old terms Grade 304. Much too often, the more corrosion resistant alloys are specified in the UK without real appreciation for the robust corrosion resistance of EN1.4301 and recognition of their cost. The use of EN1.4301 in Progreso Pier2 amply illustrates the robust nature of this alloy!

Marine Applications:

By contrast, the following two examples are definitely related to the aggressive chloride / marine environment. In both cases, EN1.4436 or related stainless steel alloy EN1.4404 were used – the latter is the more common version of 'Grade 316' used today. Essentially, it is virtually as robust as EN1.4436 and, when cast in concrete, the difference is utterly negligible. This is a particular idiosyncrasy of the British Standard which it is expected will be properly addressed when the governing European Standard is finally published.

In the case of the Brisbane City Riverwalk Floating Walkway³, much discussion took place about the use of stainless steel. Here floating pontoons made from reinforced concrete had been designed to support a walkway made of decorative railing and lighting fixtures. In a desire to find a 'cheap' solution, initially specifiers discussed the use of high tensile carbon steel reinforcement with a chemical corrosion inhibitor – calcium nitrite. The issue for the specifiers was determining what longevity could be relied upon with the cheaper option. Concern regarding cracking of the concrete during the life of the project led to a positive result for stainless steel reinforcement. With 35 mm cover and a 50 MPa concrete strength any concerns about cracking or poor workmanship in execution were more than covered by the use of a non-corroding stainless steel reinforcement.

Concrete decking helps to preserve our global ecosystem:

An exciting new development area in the use of stainless steel reinforced concrete is decking in marine applications.

Here concrete is replacing precious hardwood decking. The environmental benefits of this new initiative are obvious and highly praiseworthy. The nature of the decks calls for resistance to corrosion whilst also being thin and durable, capable of withstanding heavy equipment being dropped on the decks in a working harbour environment. Cover is satisfactorily dynamic in terms of the use of a highly corrosion resistant material with 10 mm cover and a 40 MPa strength. In this type of application the more robust type of stainless steel is called for – a 316 type or Duplex: EN1.4436; EN1.4404; EN1.4571; or EN1.4429.

Cast Stone or Semi-Dry Precast:

The semi-dry precast sector, broadly represented in the UK by the UK Cast Stone Association, use stainless steel for both reinforcement, handling and installation purposes. Uses include introduction of limited reinforcement in beams designed primarily to avoid danger to works when lifting beams and lintels which might otherwise fail during lift and handling bars for lifting and permanent installation. The stainless steel will ensure long-term work for the cast stone unit as it enables each unit to be used in structural applications.

The 'Cookie Cutter':

Even though this is as applicable to carbon steel reinforcement and, for that matter, to in situ concrete, precast does help to illustrate well the benefit of repetitive work. The Broadmeadow Bridge precast parapets comprised 66 MT of stainless steel reinforcement. Having been specified before the publication of the Highways Agency's BA84/O2, the cover was 50 mm and the engineers specified EN1.4404 /1. The parapets' design consisted of just one link /stirrup shape for all parapets. The economies of scale were substantial in terms of efficient production of the stainless steel reinforcement which translated into substantial savings to the project.



An Issue of Safety

One exceptionally important area where stainless is now being used is in precast components for concrete balconies. Historically, the reinforcement in the balcony and the cantilever reinforcement securing this to the building

structure was carbon steel. These early reinforced concrete balconies have been given the unfortunate name of the 'silent killers'. There is not necessarily any early warning of failure: e.g., tell tale bleeding through concrete and paintwork, prior to balcony failure and collapse: the corrosion bleeds back into the wall cavities rather than through the exterior surface of the concrete. Replacement by stainless reinforcement, eliminates this risk whilst not compromising the quality of concrete.

Further Development of stainless reinforcement in precast concrete:

There are many areas in which the interaction of stainless reinforced precast concrete offers exciting, elegant, reliable and cost effective solutions for the customer whilst, also, allowing the engineers to specify as if he or she were using carbon steel reinforcement.

Car parks are an obvious area for use of stainless steel. Precast slab reinforced with stainless reinforcement will withstand any corrosion induced by the wetting /drying action of wet car tyres depositing chlorides in car parks during winter use of road salt. There is no need to establish complicated engineering systems. Slab thickness can also be reduced at no expense to the performance of the car park.

Also, reinforced precast tunnelling sections where the overall cover and, therefore, quantity of concrete used for tunnelling projects are reduced. This will again assist in the logistics of delivery with reduction in concrete usage and therefore the mass of the structure.

Conclusion

It is to be hoped that stainless reinforcement used in conjunction with concrete will enable the plasticity of reinforced concrete to be tested to the limits of engineering convention. These limits are best executed in the controlled environment offered by precast production techniques.

Stainless reinforced precast concrete, if used properly, can deliver all round positive environmental benefits for the concrete industry, the contractor and customer alike.

REFERENCES:

- 1 Off-site prefabrication – the advantages of precast cladding construction, Stephen Maddalena. Concrete, July/August 2004, pp. 6-8
- 2 Performance of a 60 year old concrete pier with stainless steel reinforcement, P. Castro Borges, et al., Materials Performance, October 2002 pp. 50-53
- 3 Technical Reports – www.arminox.com.au